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(54) **Microcircuit substrate and method of making same.**

(57) Individual ceramic substrates for electronic microcircuits are formed in an array having rectangular perforations (118) which define score lines (12) along which the array is broken to yield the individual substrates. The surfaces of the rectangular perforations are metallised and leads are attached thereto by thermocompression bonding after the array is broken. The rectangular perforations result in semi-rectangular openings around the periphery of the individual substrates. This eliminates tensile forces which cause cracking of the substrate during lead bonding.

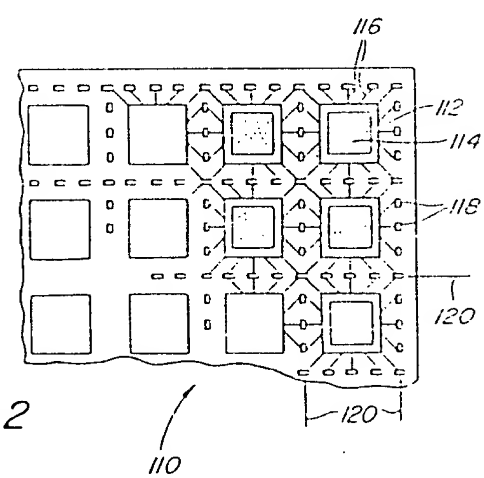

FIG. 2

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MICROCIRCUIT SUBSTRATE AND METHOD OF MAKING SAME

Technical field

The invention relates to the field of microelectronics and in particular to ceramic substrates for individual microelectronic circuits.

Background of the invention

Electronic microcircuits have enjoyed phenomenal growth since their introduction in the 1960's, and are used in a wide range of applications.

Electronic microcircuits, often referred to as "chips", may be either integrated circuits, where each individual circuit element is fabricated on a single piece of semiconductor material, or hybrid microcircuits, in which individual electronic components, including integrated circuits, are mounted on a substrate and interconnected by conductors fabricated on the surface of the substrate or by wires or both. Although the present invention will be illustrated in the context of integrated microcircuits, it should be recognised that the invention is applicable both to integrated microcircuits and to hybrid microcircuits.

Integrated microcircuits, or "chips", are typically manufactured in arrays of large numbers of individual circuits on a wafer of semiconductor material.

After manufacture, individual chips are separated from the wafer and are mounted on a substrate. The substrate supports the individual chip and the leads which enable the microcircuit to be connected to a circuit board. The microcircuit and the substrate may be encapsulated in a plastics or similar material.

The substrate is typically made either of plastics material or of ceramic material. Ceramic material has a number of well-known advantages over plastics. A ceramic substrate can be hermetically sealed, whereas a plastics substrate cannot. Ceramic can also withstand higher temperatures than plastics. Another advantage of a ceramic substrate is that during reflow soldering, the device can better withstand thermal mismatch because the ceramic expands at a predictable rate. The leads can be designed to yield to compensate for the differences in thermal expansion between a ceramic substrate and its plastics package.

Ceramic substrates are typically made out of aluminium oxide (alumina). However, other ceramic materials possessing special properties may be used. For example, beryllium oxide (beryllia) may be used when superior heat conductivity is required; titania may be used where high dielectric strength is required; and black ceramics may be used where no light emission or penetration is desired.

Although different ceramic materials offer different properties in one way or another, all ceramic materials share a common drawback. Ceramic can withstand very large compression forces but practically no tensile forces. This disadvantage has made it extremely difficult to side bond leads to ceramic substrates using thermocompression bonding or thermosonic bonding. In order to bond leads to the sides of ceramic substrates, it has been necessary in the past to braze the leads to the substrate. However, brazing has the disadvantage of

requiring high temperatures, which in turn limits the kinds of materials that can be used for the leads. For example, copper cannot be used because it oxidises at brazing temperatures.

The present invention makes it possible to thermocompression bond leads to the sides of a ceramic substrate. It is thus no longer necessary to braze the leads to the sides of the substrate. Copper leads can now be used, rather than more exotic alloys.

Summary of the invention

In accordance with the invention there is provided a method of making indivisual microcircuit ceramic substrates, characterised by:

(a) constructing an integral array of a plurality of individual substrates on a sheet of ceramic material,

(b) forming rectangular holes in the ceramic material along score lines which define the periphery of individual substrates,

(c) separating the individual substrates from the array by breaking the array along the score lines to yield individual substrates having semi-rectangular openings around the periphery of each substrate,

(d) metallising at least one surface of the semi-rectangular openings, and

(e) bonding leads to the substrate at the semi-rectangqular openings.

The bonding step preferably comprises thermocompression bonding.

The invention also includes a ceramic substrate for an electronic microcircuit made according to the method of the invention.

In order that the invention may be fully understood a preferred embodiment thereof will now be described by way of example and with reference to the accompanying drawings, in which:

Figure 1 shows an array of individual substrates in accordance with the prior art.

Figure 2 shows an array of individual substrates according to the present invention.

Figure 3 is a plan view of an individual substrate in accordance with the present invention.

Figure 4 is a partial elevation view of an individual substrate taken along the line 4-4 of Figure 3.

Figure 5 is a schematic representation of lead bonding to a substrate in accordance with the prior art, illustrating the bonding forces on the substrate.

Figure 6 is a schematic representation of thermo-compression bonding of a lead to a substrate in accordance with the present invention, showing the bonding forces on the substrate.

Referring now to the drawings, wherein like numerals indicate like elements, there is shown in Figure 1 an array 10 of individual substrates 12 in accordance with the prior art. A plurality of circular perforations or holes 18 are formed in the array 10 along score lines 20 which define the periphery of individual substrates 12. Individual substrates 12 are obtained by breaking the array 10 along the score lines. The resulting individual substrates 12 have a plurality of semi-circular openings 19 around the periphery thereof. See Figure 5.

Each individual substrate 12 has a microcircuit chip bonding area 14. Bonding area, or bonding pad, 14 is typically a metallised area to which individual microcircuit chips (not shown) are attached by conventional bonding methods, such as adhesive bonding or eutectic bonding. Individual substrates 12 also have a plurality of metallised conductors 16 which extend from an area surrounding the bonding pad 14 to the semi-circular openings 19. A metallised layer 24 of conductive material

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forms a conductive path from the surface of the opening 19 to the metallised conductors 16, in known manner. Leads are attached to the substrate 12 at the semi-circular opening 19 to permit the substrate to be connected to a circuit board. Gold or aluminium wires (not shown) are connected from the conductors 16 to locations on the microcircuit chip to complete the circuit path from the leads to the chip.

As best seen in Figure 5, the semi-circular openings 19 do not permit leads to be thermocompression bonded to the sides of a substrate 12. As illustrated schematically in Figure 5, a lead 26 to be bonded and having a rounded face 28 is placed in a semi-circular opening 19. In thermocompression bonding lead 26 to substrate 12, the lead 26 is placed in the semi-circular opening 19 and is bonded to the metallised layer 24 by heat and pressure. The lead 26 is forced against the layer 24 by a bonding force F'. The lead 26 deforms under force F' as force F' compresses the lead against the metallised layer 24. Because of the semi-circular shape of the openings 19, force F' resolves itself into radial forces F which act along radii of the semi-circular opening 19. Each radial force F has tangential components which act along tangents to the semi-circular opening 19. The net result of these forces is a tensile stress on the semi-circular openings 19. Because ceramics are very weak in tension, the tensile stress causes cracks 30 in the substrate. The cracks 30 lead to degraded electrical performance of the microcircuit chip, and usually require the device to be scrapped.

The present invention eliminates the tensile forces on the substrate which result when attempting to thermocompression bond leads to semi-circular openings. As shown in Figure 2, in accordance with the present invention an array 110 of individual substrates 112 is

constructed as in the prior art, except that the perforations or holes 118 which define the score lines 120 are rectangular rather than circular. It should be understood that "rectangular" includes holes which have four equal length sides, i.e.are square.

As best seen in Figure 3, the substrate 112 of the present invention has a bonding area 114 and a plurality of conductors 116. Each conductor 116 has a bonding pad 122 adjacent to the chip bonding area to enable wires to be connected from the conductors 116 to the microcircuit chip.

Each substrate 112 has a plurality of semi-rectangular openings 119 around its periphery. These may be formed for example by a punching operation. At least one surface of the semi-rectangular opening has a metallised layer 124 which is physically and electrically connected to the conductor 116. See Figure 4.

Figure 6 illustrates schematically the way in which a lead 126 may be thermocompression bonded to the substrate 112. The lead 126 has a flat face 128 which is placed next to the metallised area 124 and is subjected to thermocompression bonding force F'. Force F' is distributed across the area of the lead surface 128. However, because the opening 119 is semi-rectangular, there is no tangential component to the bonding force F'. Thus, all of the force F' is distributed across the metallised area 124 as compression force. Since ceramic materials can withstand very large compression forces, there is no likelihood of damage to the substrate by the bonding force. In addition, since there is no tangential component of the bonding force F', there are no tensile forces anywhere along the periphery of the holes 119. Accordingly,the danger of tensile failure is eliminated.

The present invention provides a simple, effective

way of thermocompression-bonding leads to the sides of ceramic substrates while at the same time eliminating the problems experienced with thermocompression bonding in the past. The invention enables electronic microcircuits to be manufactured simply, inexpensively and reliably.

CLAIMS:

1. A method of making individual microcircuit ceramic substrates, characterised by:

(a) constructing an integral array of a plurality of individual substrates on a sheet of ceramic material,

(b) forming rectangular holes in the ceramic material along score lines which define the periphery of individual substrates,

(c) separating the individual substrates from the array by breaking the array along the score lines to yield individual substrates having semi-rectangular openings around the periphery of each substrate,

(d) metallising at least one surface of the semi-rectangular openings, and

(e) bonding leads to the substrate at the semi-rectangular openings.

2. A method according to claim 1, characterised in that said bonding step comprises thermocompression bonding.

3. A method according to claim 1, characterised in that said bonding step comprises thermosonic bonding.

4. A method according to claim 1, characterised in that said forming step comprises punching.

5. A ceramic substrate for an electronic microcircuit made according to the method as claimed in any preceding claim.

6. A ceramic substrate for an electronic microcircuit comprising an element of ceramic material bounded by a peripheral edge, characterised in that the peripheral edge is provided with a plurality of spaced semi-rectangular recesses extending through the depth of the element.

7. A ceramic substrate as claimed in claim 6, characterised in that a metallic layer is provided on at least one surface of each of said recesses, and leads each

having a flat face are bonded to at least some of said openings.

8. A ceramic substrate for a plurality of electronic microcircuits comprising a sheet of ceramic material provided with holes therethrough defining lines along which the sheet can be broken to form individual substrates, characterised in that the holes are rectangular.

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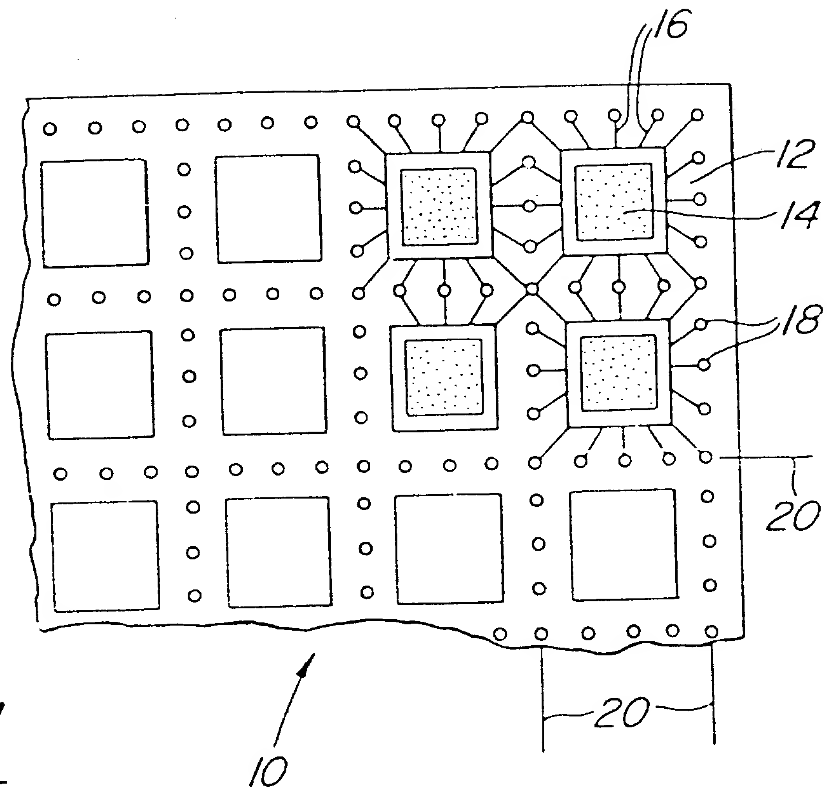

FIG. 1
PRIOR ART

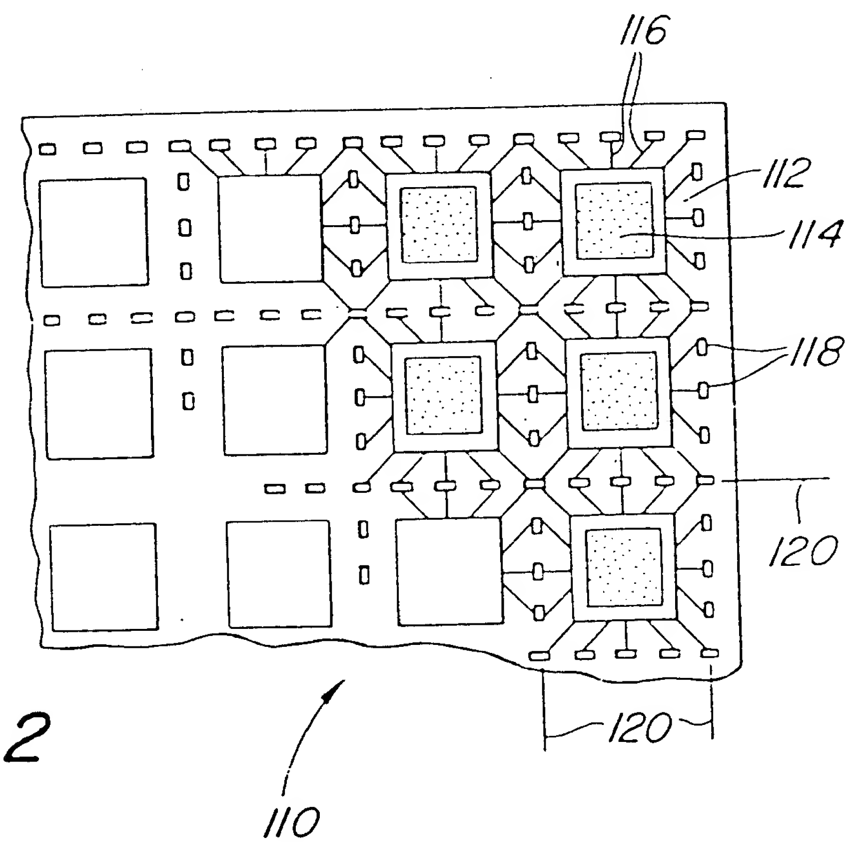

FIG. 2

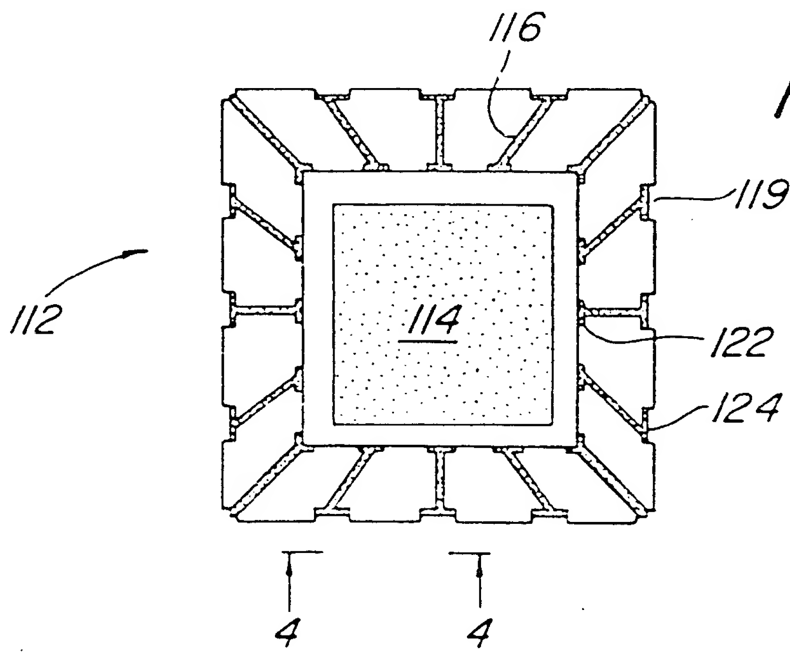

FIG. 3

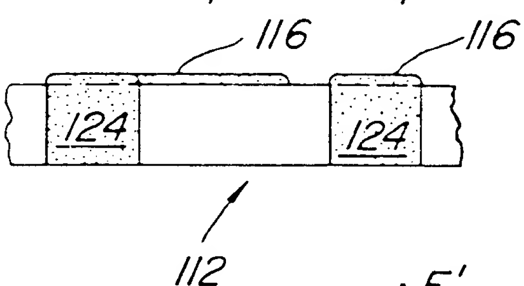

FIG. 4

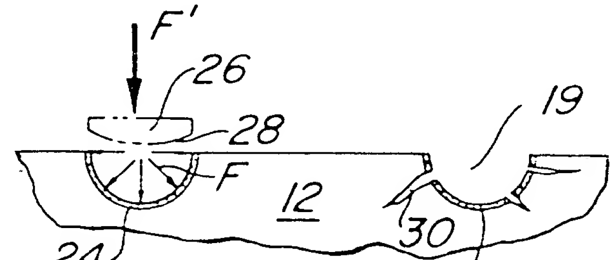

FIG. 5
PRIOR ART

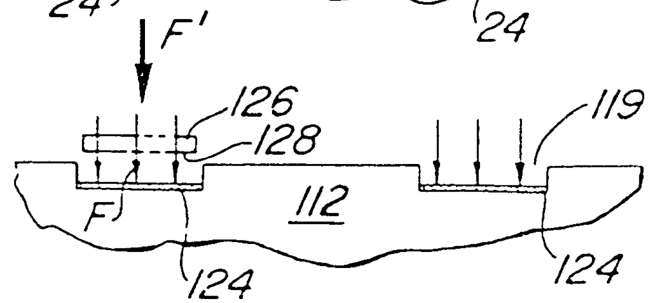

FIG. 6